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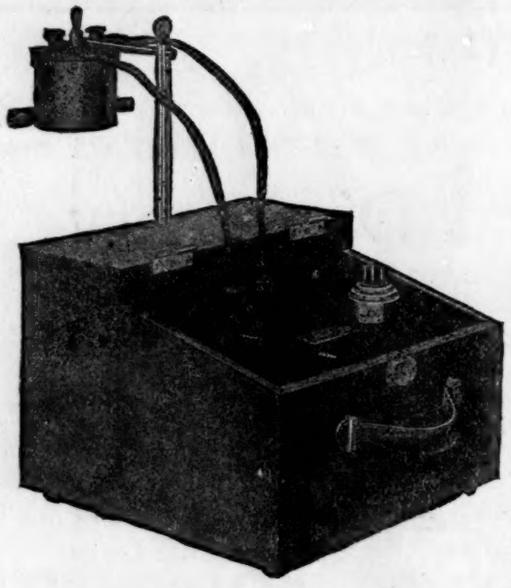

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SPHAGNUM AS A SURGICAL DRESSING[1]

THE world war has produced a "world emergency" which has stimulated to an extraordinary extent the inventive genius of this and practically all nations. This is observed not only in the great development of destructive agents as seen in certain lines of chemistry, aeronautics, submarines and gunnery, but also in the marvelous skill that has developed and the appliances used in surgery. War had been declared only a few months when it was seen that there was likely to be a shortage of absorbent cotton, and in an effort to avert such a calamity experiments were begun with sphagnum, or peat moss, as a substitute. At the present time surgical and non-surgical dressings made from sphagnum are being used in the war hospitals, not only in Great Britain, but in France, Malta, Alexandria, Salonika, Italy and Palestine—practically on all the allied fronts. Doubtless it is also used extensively in Germany, as certain returned prisoners state that part of their work was to gather sphagnum from bogs. How it was used, however, we do not know.

DISTRIBUTION OF SPHAGNUM

Sphagnum is widely distributed throughout the world, especially in the damp humid climate of the colder parts of the temperate zone of Europe, Asia and America. The British supply comes from the moors of Scotland and Ireland, and from Canada. The Germans obtain it from extensive bogs around the Baltic.

In North America it occurs most commonly along the northeastern coast from New England to Labrador, and along the northwestern coast from Oregon to Alaska. In the interior large bogs occur, especially in the region

[1] A fuller account of "Sphagnum as a Surgical Dressing" is given by the writer in a pamphlet published by the Northwest Division of the American Red Cross, Seattle, Washington.

of the Great Lakes. Thus far, however, moss suitable for surgical dressings has not been reported in any large quantities from this region. The excessive heat in summer and the extreme frost in winter creates a condition that is uncongenial for desirable species to grow and thrive.

On the Pacific coast, extending from Oregon to Alaska, large numbers of sphagnum bogs occur. It is estimated that in Washington alone there are 25,000 acres of cranberry marsh. Of course a large proportion of this area does not have usable moss. Most of the bogs in Washington that are close to the Pacific Ocean are "raised bogs," that is, the center is higher than the margin, often a foot or more. Consequently, surrounding each of these is a marginal ditch filled with water. Raised bogs also occur along the northern Atlantic, especially in Nova Scotia and Newfoundland. This type of bog occurs only where there is an excessive amount of moisture and thus most congenial for the growth of sphagnum. Moreover, it is this kind of bog that usually contains the species most suitable for surgical dressings. Hence the most promising fields for the location of suitable surgical moss may be expected along the northern Atlantic and Pacific coasts.

USES OF SPHAGNUM

Sphagnum is frequently called "peat moss," because it, with other plants growing in undrained bogs, eventually make peat, which is used extensively for fuel in some countries. Sphagnum is very commonly used by nurserymen and others for packing; especially is it desirable about the roots of plants when moisture is required for a considerable length of time. A number of varieties of orchids thrive as well in sphagnum as in their native haunts. This moss makes an excellent insulator, much better than sawdust or even cork, but of course it can not be used where it is exposed to moisture. It excels sawdust as a medium for packing and shipping raw fruits, like grapes, because when one bunch "goes bad" the moss immediately absorbs the moisture and prevents the infection spreading. In Sweden some of the coarser kinds of paper, like wall-paper, wrapping paper and building paper, are made from this moss. It is used in Alaska and other places where it is abundant to bind up wounds of domestic animals, particularly when there is some discharge. In such cases the moss is applied directly to the wound. When it is dried it is often used as bedding for horses and other animals. This moss has also been used in Scotland and Ireland as a home remedy for absorbing the discharge from boils and other suppurating wounds. The American Indians made use of dried sphagnum for diapers for their babies. In Alaska they still do it. The Alaska Indians also make a very wholesome salve, used for cuts, by mixing sphagnum leaves with tallow or other grease and working the two well together.

It is known that in Germany a fairly good cloth is made by mixing sphagnum with wool and weaving them together. Promising results have also been obtained when it is used as a fertilizer. Not that it adds much plant food to the soil, but that it acts as a stimulant by holding a large quantity of water. It is of particular value when applied to the roots of trees along parking strips in cities.

Dr. Walton Haydon, of Marshfield, Oregon, used sphagnum extensively while in the service of the Hudson Bay Company at Moose Factory during the years 1878–1884. After the moss was collected and sorted it was sprinkled with a weak solution of carbolic acid. When nearly dry it was stored in a jar with a tight cover until used. In using it a thin cotton dressing was laid on the wound or sore, then a layer of moss and the whole dressing wrapped with a bandage. Dr. Haydon found it best to keep the sphagnum with a small amount of antiseptic moisture in it, as it breaks up and becomes dusty when thoroughly dried.

Sphagnum was used or at least recommended for use during both the Napoleonic and Franco-Prussian wars, and was employed to a limited extent in the Russo-Japanese war. It was not, however, until the present world

war broke out that it became extensively employed as a modern surgical dressing.

Shortly after the war was declared in 1914, Dr. C. W. Cathcart, an Edinburgh surgeon and a lieutenant-colonel in the medical corps of the British army, began experimenting with sphagnum in one of the Scottish hospitals. The first published account of these experiments, together with the general account of the moss as a surgical dressing, appeared in the *Scotsman* of November, 1914.[2] Dr. Cathcart then formed an organization for collecting and preparing the peat moss for surgical pads in Edinburgh. This was the first organization formed for this purpose among the allied nations. In September, 1915, a second one was established in the south of Ireland by the Marchioness of Waterford. The work thus begun was so promising that new organizations sprang up all over Scotland and Ireland under the War Dressing Supply Organization in Edinburgh, and the Irish War Hospital Supply Depot in Dublin. During this experimental stage there was considerable opposition to this kind of surgical pad, but as time went on and the method of making the dressings was improved, this opposition disappeared and in February, 1916, the British War Office accepted them as "official" dressings. With this recognition and organization the work rapidly increased, so that during the summer of 1918 the sphagnum pads produced by Great Britain are numbered in the millions per month, Scotland alone being asked to supply 4,000,000 sphagnum dressings a month.

In America the sphagnum work on a large scale, has been more recent. During the summer of 1916, Dr. J. B. Porter, of McGill University, became interested in peat moss for surgical dressings.[3] Samples were collected in eastern Canada, especially in Nova Scotia, and sent to Britain for approval. It was late in the season before definite reports could be obtained from these samples, so little was done before the bogs were frozen.

In the spring and summer of 1917 this work was continued by the Canadian Red Cross under the direction of Dr. Porter. Although no very large number of dressings was made, yet the organization was extended and perfected, and the bogs containing the desirable moss located, so that if the demand became more urgent the production of this kind of dressing could be readily pushed. This demand came in January, 1918, in the form of an order from the British War Office, for 20,000,000 sphagnum surgical dressings. The Canadian Red Cross is thus doing extensive work along this line during 1918.

After the United States entered the war more interest was taken in this work by Americans but it was not until March 1, 1918, that sphagnum was officially recognized by the National Red Cross of America. At that time a preliminary order for 50,000 pads was given to the Seattle Chapter and these have been made on the campus of the University of Washington under the direction of the writer.

The faculty of the University of Washington, feeling the importance of this phase of War Emergency work and wishing to assist in completing as rapidly as possible this large allotment of pads, voted to require all women of the first and second years of the university to register for two hours a week for moss work during the spring quarter. The request for this work came originally from the women themselves through the dean of women. They felt that since the men were required to devote eight hours a week to military drill without university credit, the women also should do some definite war work under university supervision.

COLLECTING AND SORTING

Before beginning the collection of sphagnum one should know exactly what is needed. There are over forty species of this moss in America of which only four (*S. imbricatum, S. palustre, S. papillosum* and *S. magillanicum*) are at present used for surgical dress-

[2] Charles W. Cathcart and I. Bayley Balfour, "Bog Moss for Surgical Dressings," *The Scotsman*, No. 17, 1914.

[3] John B. Porter, "Sphagnum Surgical Dressings," *International Journal of Surgery*, May, 1917.

ings. Great care should thus be exercised in order that only suitable moss be collected. To this end it is often wise to carry a sample of approved sphagnum for comparison until one is quite familiar with the work.

In the bog it has been found most convenient to take a small handful of moss at a time and to shake it lightly to get rid of most of the foreign matter, such as leaves, twigs, roots, etc. If wet, squeeze out as much water as possible before putting it in the bag, but do not wring it, as that will break and injure the stem.

The depth to which usable moss extends varies with the species and environment. In many cases beds of *Sphagnum imbricatum* may be worked to advantage a foot to eighteen inches or even farther, depending on whether the plants remain intact or whether a partial decay has begun. In general, whenever the plants begin to break up as a result of the first stages of decay, they must be discarded; but as long as they remain intact, with stem fairly well crowded with lateral branches, they may be used, the color playing little or no part in determining the suitability. While gathering moss it is wise to secure all the good moss in a given space before proceeding to another, because after a growth has once been disturbed the adjoining plants usually deteriorate and sometimes die.

After it is taken from the bog the moss should be removed to some shelter and spread out to dry. This may be done on the grass if the weather is fine, otherwise on suitable racks which usually prove more satisfactory, or on the floor of some empty building, although care must be taken not to put it on valuable flooring, as the dampness is apt to do some damage.

The collection of moss is one of the most important phases in the making of sphagnum pads. Much depends upon the condition of the moss when it reaches the sorter if their work is to be most efficient. It has been found that carelessness or thoughtlessness on the part of the collector often decreases the efficiency of the sorter far out of proper proportion.

The most tedious part of making sphagnum pads is picking over and sorting the moss, and this is greatly increased by careless gathering. The sorting should be done in some central place and completed before the moss is dry. If inadvertently the moss becomes too dry it should be spread out in a gentle rain for a short time or sprinkled with water and left over night with an oil-cloth spread over it.

How Sphagnum Pads are Made

Like many other things in connection with this war, the directions for making surgical dressings from sphagnum have not been static, but progressive. From time to time valuable suggestions as to where the pads could be improved have been received from surgeons at the front who have been actually using them. Acting on these suggestions, the British have gradually increased the efficiency of their moss dressings. More recently the American Red Cross, after some experimentation under the direction of Dr. John A. Hartwell, has adopted a different dressing which promises to be even more efficient than the one authorized by the British War Office. But the last word has not yet been said on sphagnum for surgical dressings. The American type of sphagnum dressing is composed of gauze, a thin sheet of wood pulp paper, non-absorbent cotton and sphagnum. The sizes of the dressings will vary from time to time as the War Department may recommend. The first half million pads allotted to the Northwest Division of the Red Cross consists of two sizes, 8 in. by 12 in. and 12 in. by 24 in.

In making one of these dressings, a piece of Zorbik or Scott tissue[4] of appropriate size is placed on the table and on it a wooden frame corresponding to the particular size to be made. The frame, which is about three quarters of an inch deep, is filled evenly with moss over which a thin layer of non-absorbent cotton is placed and then the frame removed. The margins of the tissue are then folded over the cotton and sphagnum. It is usually convenient to use spring clothes-pins to hold

[4] Zorbik or Scott tissue is a very thin wood-pulp paper used to envelop the sphagnum and prevents it from sifting out.

the ends in place, although this is not absolutely necessary. In order to keep the outside covering free from particles of moss it is best to remove this incomplete pad to another table where there is no moss. Here it may be finished by the same worker or by another. A piece of gauze of appropriate size is spread out on the table and the incomplete pad is placed in the center of it, with the non-absorbent cotton up. A thicker layer of cotton is then put over the pad, extending about a quarter of an inch beyond the edges. The gauze is folded over the pad so that the long fold is on the back, that is, on the side next the non-absorbent cotton.

The open ends are folded in "muff-wise," first folding the under side up over the tissue-envelope, then folding the upper side to correspond and adjusting the "muff-end" carefully. The pad is patted lightly to make sure the sphagnum is evenly distributed throughout and then passed through a clothes-wringer. If, when held up to a strong light, "holes" are detected in the pad, too little moss has been used. If the pad is solid and harsh, there is probably too much moss.

The British type of sphagnum pad consists of a flat bag made of English long cloth with a fine enough weave so that the particles of moss will not sift through. This bag, which varies in size according to the need, is filled with the appropriate amount of moss and sewn up.

The Canadian Red Cross adopted three types of sphagnum dressings, the British type just mentioned, a standard dressing similar to the American type and bed pads made of second grade sphagnum. During the summer (1918) the Canadians are concentrating most of their energy on the standard dressing, while a smaller number of the British type and comparatively few of the bed pads are being made.

SUMMARY

1. The use of sphagnum as a substitute for absorbent cotton is not only a great saving of money but is fast becoming an absolute necessity on account of the acute shortage of cotton, due, in part, to the extensive use in explosives.

2. It has been estimated that if absorbent cotton were used exclusively in the hospitals the cost would be not less than $200,000 per annum for Great Britain alone, while the cost of the moss is practically negligible.

3. The value of sphagnum as a surgical dressing lies chiefly in its absorbency. The species used for this work will absorb and hold fourteen to twenty times their weight of water. Ordinary absorbent cotton will hold only four or five times its weight.

4. The sphagnum is not subjected to any special treatment for surgical dressings but simply gathered from the bog, the foreign material removed, dried and made into pads which are sterilized after they get to France.

5. There is some indisposition on the part of American surgeons in France to use these pads. This is what was anticipated as surgeons are, to say the least, conservative in connection with their supplies, etc., and generally speaking indifferent as to the expense of these supplies. The British Army Medical Service went through the same thing two years ago and even up to last year sphagnum dressings were looked upon as an undesirable make-shift by a great many British surgeons; but at last they seem to have come into their own, as can perhaps best be illustrated by the fact that Canada has been given an allotment of 20,000,000 and that Scotland has been recently asked to turn out 4,000,000 sphagnum dressings a month.

6. Although sphagnum for surgical dressings has been largely the result of the present war, a make-shift for a necessity that had arisen, yet there seems every reason for believing that it is not going to be discarded after the war ends. The inexpensiveness of the moss, its high absorbency, its abundance in certain parts of the country and its undoubted superiority over gauze and absorbent cotton for some purposes, clearly indicated that it is too important as a hospital equipment to let die with the war. When the war is over it will probably take its place among the regular commercial products called for by modern hospitals.

7. The last word has not yet been said regarding sphagnum for surgical work. Ex-

periments are constantly going on, looking towards both the improvement in these dressings and also in the extension of the usefulness of sphagnum along other lines.

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Seattle, Wash.

A NEW SEASONAL PRECIPITATION FACTOR OF INTEREST TO GEOGRAPHERS AND AGRICULTURISTS

Most persons who have attempted to correlate soils and vegetation with atmospheric precipitation have directed their attention chiefly to the total annual rainfall and its variations from place to place.[1] It has long been recognized that seasonal distribution also needs to be taken into consideration, but there has been no unanimity as to how seasonal variations of rainfall should be treated. Some have simply mapped the total precipitation for each month or season separately, or indicated the months of maximum rainfall in different regions; but a more common method has been to map the percentage of the total occurring in the six middle months of the calendar year, April to September inclusive.[2] Such an arbitrary division is rather unscientific, however, for in the eastern United States, if not throughout the northern hemisphere, the warmer half of the year usually extends from the latter part of April to the latter part of October, so that May to October inclusive would more nearly represent it.[3] The use of the earlier period has been defended on the ground that April rain is more beneficial to crops than October rain, which is probably true (and so would March rain be better than September rain); but the type of rainfall that is best for crops, other things being equal, is not necessarily best for soil in the long run. A warm rain presumably has a greater leaching effect than cold rain or snow, and regions subject to heavy summer rains, like most of Florida, generally have poorer soils and more swamps than where the summers are dry, as in California.[4]

In recent years the writer has calculated the rainfall percentages for May to October and also for June to September for numerous stations in the southeastern states, and thereby shown some interesting correlations with soil and vegetation.[5] But when these factors are mapped for the whole United States the correlation does not work out so well. For the northern part of the Great Plains has about the same proportion of its total rain in summer as peninsular Florida, but very different soils and vegetation. Of course part of the difference is due to the fact that the total rainfall and average temperature are much less on the Plains than in Florida. But there is another important climatic difference.

In the Great Plains and much neighboring territory the bulk of the rain falls in early summer, while along the Atlantic and Gulf coasts there is generally more rain in late summer than in any other equal period. Consideration of this fact recently led to some comparisons between early and late summer rainfall for the whole United States. After some experimenting it was found that the most striking results were obtained by taking the difference between the rainfall for April to June inclusive and that for August to October inclusive,[6] the former being good for the

[1] For such correlations between soil and rainfall see Bulletin 3 of the U. S. Weather Bureau, by E. W. Hilgard, 1892. A review of this, which may be more accessible than the original, can be found in the *Experiment Station Record*, 4, 276–282, October, 1892.

[2] For a map of the United States on this principle see Plate 2 in U. S. Geological Survey Water Supply Paper 234, 1909.

[3] See *Geol. Surv. Ala. Monog.* 8, 24; *Bull. Torrey Bot. Club*, 40, 395, 1913.

[4] Dr. A. D. Hall, of Rothamsted, in an address on agricultural extension problems published in the *Popular Science Monthly* for October, 1914 (p. 349), says: "Winter rain is more valuable than summer."

[5] See *Bull. Torrey Bot. Club*, 37, 415–416; 40, 395; 41, 556–557; *Geol. Surv. Ala. Monog.* 8, 19 24, 36, 1913; *Fla. Geol. Surv. Ann. Rep.*, 6, 182–184, 1914; also Ward in *Bull. Am. Geog. Soc.*, 46, 47, January, 1914.

[6] If climatological data for fractions of months were available we could include the first half of July in the early summer period and the second

crops and the latter bad for the soil. Data for a few hundred stations were taken from Bulletin Q of the U. S. Weather Bureau, which although it brings the records down only to the end of 1903, and contains a few typographical errors in the figures, is easier to handle than any later publication covering the same ground, and is probably accurate enough to base a working hypothesis on.

The resulting map differs considerably from any other precipitation map, but instead of publishing it in its present imperfect state a brief description will be given. The line of equilibrium, where there is no difference between early and late summer rainfall, crosses the St. Lawrence River in northern New York and extends in a general southwesterly direction, with various sinuosities (perhaps due largely to differences in altitude and exposure between neighboring weather stations in the Appalachian region) to the vicinity of New Orleans, thence westward, passing between Houston and Galveston, to near Del Rio on the Rio Grande, northwestward across the Staked Plains to the Rocky Mountains in Colorado, westward to Monterey County, California, and then southeastward just back of the Coast Ranges into Mexico. Another part of it separates the northern half of Michigan, northeastern Minnesota, and part of Wisconsin from the states to the southward, then passes northwestward into Canada and dips back into the United States just enough to cut off the north end of Idaho and the northwest corner of Washington. The borders of the United States are mostly in the region of late summer excess, while approximately three fourths of the country, including almost the whole area drained by the Mississippi River, has an early summer excess. The greatest late summer excess, about 11 inches, is on the east coast of Florida,[7] and the mouths of the Mississippi and Rio Grande are not far behind. The Black Hills have an early summer excess of about 6 inches, and the area having more than 4 inches extends all the way from Montana to Alabama. If ratios instead of differences had been used the position of the zero line would have remained the same, but the gradient would have been steepened in the drier parts of the country.

The map here described suggests at once some very interesting correlations. Considering other climatic factors first, nearly all our tornadoes occur in the region of considerable early summer excess of precipitation, and our hurricanes in that of considerable late summer excess, while regions where the difference is not more than an inch or two either way rarely suffer much damage from wind. Both tornadoes and hurricanes usually occur during the period of greatest rainfall in their respective regions.[8]

The late summer rains commonly come in the form of showers in the daytime, while the

half in late summer, and perhaps get still greater contrasts.

[7] Nassau in the Bahamas, about 180 miles farther east, has a late summer excess of nearly 13 inches.

[8] There is a tornado frequency map of the United States by J. P. Finley in Professional Paper No. 7 of the U. S. Signal Service (1882), reproduced on a smaller scale with fewer details by R. DeC. Ward in *Quart. Jour. Roy. Meteorol. Soc.*, 43, 323, 1917. This is based on 600 tornadoes occurring between 1794 and 1881, but is a little misleading, because in the early part of that period the regions where tornadoes are most frequent were practically uninhabited by civilized man, and thus the apparent frequency of such phenomena in the older states is exaggerated. Of the 40 tornadoes prior to 1850 reported by Finley, 9 were in New York, 5 in Ohio, 3 in Connecticut, 3 in Georgia, and none in Kansas and Illinois, which now lead the list. A map based on records from about 1870 to date would be more accurate; but even Finley's map shows a fair degree of correspondence between tornadoes and early summer rainfall excess.

It appears from Bulletin X. [not 10] of the U. S. Weather Bureau, on Hurricanes in the West Indies, by Dr. O. L. Fassig (1913), that there are only three well-marked hurricane regions in the northern hemisphere, all lying between latitudes 5° and 30° N., and all having a maximum storm frequency in September. In the United States hurricanes are most frequent in Florida, but they are occasionally felt as far north as the coast of Massachusetts.

early summer rain is more likely to fall gently, and at night. In the southwestern semi-arid late summer rain area (*i. e.*, Arizona, New Mexico and adjacent territory) the railroads have been put to considerable expense to build dikes to protect their tracks from sheet-floods following summer showers, while in northern Nevada and Utah, where the total precipitation is about the same, but its seasonal distribution different, no such precautions seem to be necessary. Floods of the ordinary type, caused by overflowing rivers, are much more frequent and destructive in the region of early summer rains, however.

If there was such a thing as a soil fertility map of the United States it would be seen at once that the most fertile soils are in the region where there is more rain in early summer than in late summer, and vice versa. Considering texture only (for we now have much more complete data on that than on chemical composition), we can ascertain from published soil surveys that silt loam—which is usually considerably above the average in fertility—is one of the commonest types of soil throughout the Mississippi valley, whether it is derived from weathered Paleozoic rocks, as in Tennessee, from glacial drift, from glacial lake deposits, as in North Dakota, or is of æolian origin, as the loess of Arkansas and Mississippi is supposed to be. Clay loam and stony loam are other common types in the same area, nearly or quite as fertile as the silt loam, while sand is chiefly confined to the banks of streams. The black prairies of Alabama and Texas, characterized by very fertile calcareous clays, are both in the area of early summer excess of rain, although when semi-annual percentages only were considered, as heretofore, the line of equal summer and winter rains passed between them. One would naturally suppose the flood-plain of the Mississippi below the mouth of the Ohio to be one of the most fertile tracts in the world; and so it is where it has more rain in early summer than in late summer, and most of the farmers in that portion use no commercial fertilizer whatever. But in several parishes below New Orleans, where the late summer rain is in excess, the average expenditure for fertilizers in 1909 was over a dollar per acre of improved land! (For the whole United States at the same period the average was about 24 cents.)[9]

The regions of heavy late summer rain are characterized by poor sandy soils, classed by the U. S. Bureau of Soils as sand, sand-hill, sandy loam, fine sandy loam, etc., and silt loam and clay are comparatively scarce. The sandiest extreme is in peninsular Florida, but northern Michigan, Cape Cod, and southern Texas are also notoriously sandy. Swamps too are about as prevalent in northeastern Minnesota and northern Michigan as they are in Florida. Although the late summer rain area covers only about one fourth of the United States and produces considerably less than one fourth of the crops, it uses at least three fourths of the commercial fertilizer; the average annual expenditure for that in some of the southeastern counties of Florida at the time of the Thirteenth Census being about $30 per acre.[10] And even in California there is considerable fertilizer used in the southeastern portion.

In all these eastern sandy and swampy areas the streams carry very little sediment and do not fluctuate much. In the corresponding parts of the Southwest there is not so much sand, but the type of soil known as adobe (and used extensively for building material) is very characteristic.

The distribution of vegetation types is of course correlated with the soil to a considerable extent. Except in the Northwest the forests of the early summer rain area are composed almost wholly of deciduous trees, and there are vast areas of prairie; while conifers, especially pines, predominate in northern Wisconsin, Cape Cod, southern New Jersey, Florida, and many other places where there is more rain in late summer. The most extensive pine forests in North America are said by Professor Sargent[11] to be those of western

[9] In this connection see Science, II., 42, 500-503, October 8, 1915.

[10] See *Geog. Review*, 4, 225, September, 1917.

[11] "Manual of the Trees of North America" (1905), p. 16.

yellow pine in northern Arizona and New Mexico. Most of the cacti in the United States are restricted to the southwestern area of late summer rains, and the same might be said of the species of *Yucca* and related genera.[12] (Both groups consist entirely of evergreens, and both have also several representatives in the Southeast.) The gymnosperms other than conifers (*i. e.*, Taxaceæ, Cycadaceæ, Gnetaceæ), as well as the palms and Ericaceæ, show a somewhat similar preference for late summer rain, in the United states at least.

The same precipitation factor seems to control indirectly several economic features. For example, most of the developed water-powers in the United States are within two or three hundred miles of the line of equilibrium between early and late summer rains, though this may be chiefly because the same topographic factors that make the water-power possible also influence the seasonal rainfall in some way. Some correlations between seasonal rainfall and crops are easily made. Alfalfa, wheat, figs and upland cotton are not raised much where the late summer rainfall exceeds that of early summer by more than three inches, while sugar-cane, pineapples, grape-fruit and sea-island cotton thrive where late summer rains prevail. But of course the soil has a great deal to do with this too.

It would be interesting, and comparatively easy, to determine how far the same seasonal precipitation factor can be correlated with soils, vegetation, etc., in other parts of the world. The explanation will not be quite so easy, for cause and effect are involved in a complex manner. Some of the marked soil differences between the Mississippi valley and the Atlantic coastal plain can be explained very well on geological grounds, wholly independently of modern climatic factors; and it may be that the deciduous forests and prairies that characterize the richest soils are conducive to early summer rains, and *vice versa*, in some way not yet understood.

The factor here discussed probably does not have exactly the same significance in cold as in warm climates, in humid as in dry, or in regions of wet winters and dry summers, like the Pacific coast, as in regions with wet summers, like Florida. All this deserves further investigation; and it may be found that by shifting a little the periods compared more significant results can be obtained.[13]

ROLAND M. HARPER

COLLEGE POINT, N. Y.

[12] See Plate 99 in the 13th Annual Report of the Missouri Botanical Garden, 1902.

[13] The interested reader would do well to consult Professor R. DeC. Ward's paper on rainfall types of the United States, in the *Geographical Review* for August, 1917, and some of the earlier literature referred to therein and in the two pages following it.

PLANS FOR THE PHYSICAL RECONSTRUCTION OF DISABLED SOLDIERS[1]

THE Surgeon-General, with the approval of the General Staff, announces the completion of plans for the physical reconstruction of disabled soldiers in the general military hospitals. These plans are formulated with a view to close cooperation with the War Department committee on education and special service in the work of restoring men to full or limited military service, and with the Federal Board for Vocational Education, which is authorized by the law to provide vocational training for disabled men after their discharge from the army and navy.

The records of 516 cases treated in four hospitals shows 134 men able to return to full military duty, 210 fit for limited service, and 172 who are eligible for discharge. In the last group 12 are classed as helpless or institutional cases; 121 are able to return to their former occupations; and 39 will need further training to fit them for earning a livelihood. These figures show the division of responsibility in the work of reconstruction.

The task of fitting men for further military service is at present the most pressing need because wherever an able-bodied man behind the lines can be replaced by one less fit physically, but vocationally capable, a soldier is gained for active duty. The reconstruction work in the hospitals, therefore, will emphasize tech-

[1] Publication authorized by the War Department.

nical training in all lines capable of adaptation to the physical limitations of disabled men and in which employment will act as a therapeutic agent. When play and work and study will help a man to get well, this kind of medicine will be prescribed to the patient. If the work he does leads to further service in the army or to better prospects in civilian life so much the better.

The Surgeon-General has designated the following general military hospitals for the work of physical reconstruction:

Walter Reed General Hospital, Washington, D. C.
General Hospital No. 2, Fort McHenry, Md.
General Hospital No. 3, Colonia, N. J.
General Hospital No. 6, Fort McPherson, Ga.
General Hospital No. 7, Roland Park, Baltimore (for the blind).
General Hospital No. 8, Otisville, N. Y.
General Hospital No. 4, Fort Porter, N. Y.
General Hospital No. 9, Lakewood, N. J.
General Hospital No. 11, Cape May, N. J.
General Hospital No. 16, New Haven, Conn.
General Hospital No. 17, Markleton, Pa.
Letterman General Hospital, San Francisco, Calif.
United States Army Hospital, Fort Des Moines, Iowa.
Plattsburg Barracks Hospital, Plattsburg Barracks, N. Y.
General Hospital, Fort Bayard, N. Mex.

The policy to be followed in these hospitals, as announced by the Surgeon General, is that hereafter no member of the military service disabled in line of duty, even though not expected to return to duty, will be discharged from service until he shall have attained complete recovery or as complete recovery as may be expected when the nature of his disability is considered. In furtherance of this policy, physical reconstruction is defined as complete mental and surgical treatment carried to the point of maximum functional restoration, both mental and physical. To secure this result all methods recognized by modern medicine as conducive to cure will be utilized. In other words, not only the ordinary means of medicine and surgery, including all specialties, will be utilized, but also physical measures such as are employed under physiotherapy, including hydro, electro and mechanotherapy, active exercises, indoor and outdoor games and passive exercise in the form of massage. Provision in the form of adequate buildings and equipment for physiotherapy have been adopted in each of the hospitals.

Modern medicinal treatment does not end with physical cure. Functional restoration is the final aim of the modern physicians and surgeons. It is conceded that the physical rehabilitation of disabled men is peculiarly dependent upon their mental attitude. The more serious the disability, the greater the danger of mental depression and an indisposition to respond to medical and surgical treatment. The educational work should begin, therefore, at the moment when the man has arrived at the stage where he begins to worry about his future, whether in this country or overseas. The first problem is to divert his attention by simple recreation, through reading, pictures, games, handiwork occupations, and the like, with a view to securing a genuine interest in the attainment of some worthy end—the end most certain to hold his attention and to claim his best efforts in his future vocation. Hence, by gradual steps he may be induced to supplement his previous vocational experience by academic, scientific or technical instruction, or to choose a new vocation and begin preparation for it if such a course is necessary.

The need of "cheer-up" work in the hospitals extends to all who are mentally capable of planning for their own future. This means a relatively large proportion of the entire number. The beginning is made at the bedside with handicrafts of various kinds grouped under the term "occupational therapy." When the man is able to leave the ward and can be benefited physically by technical training, he has the opportunity of working at specific trades either in the curative workshop, in specially provided classrooms, or out of doors.

The teachers for this work have been secured from the convalescent disabled soldiers who are already skilled in their vocations and from the enlisted personnel of the army secured by transfer or by induction of regis-

trants disqualified for general military service but qualified for special limited service. These instructors work under the direction of educational officers chosen for their professional standing in civil life and commissioned in the Sanitary Corps of the Medical Department. The General Staff has just authorized commissions for 119 educational officers for this purpose.

From the military standpoint disabled soldiers may be placed in three general classes: (*a*) Those who can be restored to full duty. (*b*) Those who can be fitted for limited service. (*c*) Those disabled to the extent of unfitting them for further military service.

It is the announced policy of the Surgeon-General that patients of the first class (*a*) should have, when circumstances warrant it, the benefit of therapeutic treatment through play, work, and study, as may be prescribed by medical officers, in order that their morale may be stiffened, their special skills improved, their future usefulness increased and their recovery hastened.

Patients of the second class (*b*) should have, whenever conditions permit and the medical officers approve, such specific training—physical and vocational—as will in the judgment of the educational officers best fit such patients for limited service of a particular kind. At present patients are being trained in general hospitals for limited service as general and vocational teachers, typists, printers, tailors, cobblers, harness makers, welders, motor mechanicians, painters, machine workers, woodworkers, bookkeepers, statisticians, telegraphers, photographers, telephone operators, cooks, storekeepers, electricians, etc.

The list will be extended with the advice and cooperation of the committee on education and special service of the War Department to meet other needs as they arise. In connection with the large general hospitals there is abundant opportunity for practise in many trades and occupations. At Fort McPherson, for example, practical experience can be gained in twenty different trades. Moreover, there is immediately adjacent to the hospital a large quartermaster's mechanical repair shop, covering all phases of mechanical repair and construction to which men can be assigned for limited service or to gain experience.

Patients of the third class (*c*) should be encouraged in every possible way to accept the benefits accorded them for vocational training by the Federal Board for Vocational Education. To this end they should have while in the hospital such physical training and general education as will best promote their physical reconstruction and at the same time contribute most to their vocational training. Patients who do not elect or who are not eligible to continue their education under the Federal board should receive such training as the medical and educational officers deem best in each individual case.

GEORGE ARCHIBALD CLARK

PROFESSOR GEORGE ARCHIBALD CLARK, academic secretary of Stanford University, died on April 27, 1918, at his home on the campus of the university, after a prolonged illness from a disease that had baffled his physicians. Mr. Clark's illness began more than a year ago with an attack of grip from which he never fully recovered. His legs became so weakened or paralyzed that he was for some time able to walk only with the aid of a cane, and later scarcely at all. He continued to go to his office until last August, and after he was no longer able to do so he continued to look after business matters from his home. His work as academic secretary was hard and exacting and of such a nature that many of the details could not be entrusted to his assistants. This close confinement and constant attention to official duties doubtless had much to do with bringing on the fatal illness.

Mr. Clark was fifty-three years old. He graduated at the University of Minnesota in 1891. In the fall of that year he went to California and registered as a graduate student in Latin at Stanford University which was then just entering upon its first year. Being an expert in shorthand, Mr. Clark was offered a position as stenographer in the university. In 1896 he was made secretary to President Jordan. His unusual ability soon

led to his appointment as secretary of the university, a title a little later changed to that of academic secretary.

Although his office duties were of the most exacting nature, he nevertheless found time to do some teaching. In 1911–12, he offered a course in commercial teachers' training in the department of education, which he later broadened to general secretarial training

In 1896, when David Starr Jordan was made the United States member of the International Fur Seal Commission, Mr. Clark was appointed secretary to the commission. In this capacity Mr. Clark accompanied the commission to the Pribilofs, where he spent many weeks on the seal islands, studying the seals on the rookeries and doing the exacting clerical work of the commission.

He remained as secretary to the commission during the entire period of its existence and visited the seal islands again in 1897 and 1898. During the sittings of the commission in Washington in the winters of those years to Mr. Clark fell the almost herculean task of collating, arranging, classifying and presenting to the commission in proper form for their consideration, the stupendous amount of historical, commercial, political and biological data which the State Department, the Treasury Department, and particularly the commission itself, had assembled. To do this required unusual abilities in a number of lines, including diplomacy, as well as the strength of body and will to work eighteen to twenty hours every day for several weeks. No one but Dr. Jordan, chairman of the commission, and one or two others connected with it, ever knew or realized the invaluable service which George A. Clark rendered our government in those critical days.

The interest in fur-seal matters developed then remained with Mr. Clark to the last. It was he who planned and actually took the first reliable census ever made of the fur-seal herd. So great was his interest in the fur-seal problems and so clearly was his exceptional grasp of those problems realized by the government, that he was again sent to the islands in 1909, 1912 and 1913, by Hon. Charles Nagel, Secretary of Commerce and Labor and George M. Bowers, Commissioner of Fisheries. In each of those years he made a careful census of the fur-seal herd. It was the belief of Mr. Clark and those then in charge of the fur-seal service in the Bureau of Fisheries that a reliable census of the herd for a series of years, together with carefully carried out marking, weighing and other observational studies of the seals, would put the government in possession of knowledge regarding the age of maturity, reproductive period, rate of natural increase, natural mortality, rate of growth, habits of the yearling and two-year-old males and females, and a number of other problems concerning which the lack of definite knowledge has been the cause of most of the disputation regarding fur-seal matters.

So long as killing seals in the open sea was lawful and practised, some of the most important of these questions could not be solved. With the cessation of pelagic sealing, resulting from the convention of July 7, 1911, entered into by the United States, Great Britain, Japan and Russia, it then became possible to make such a scientific study of the fur-seal herd as would give the government the exact knowledge so long and so seriously needed. The government would then be in a position to formulate and put into effect a rational policy for the management of the fur-seal herd.

The season of 1912 was the first in which there was no pelagic sealing. The fur-seal herd was then the smallest in its history. Then was the time to begin its scientific study, according to a carefully thought-out program, to extend over a series of four or five years. It was believed that period would be sufficient to solve the vitally important problems before the herd became so large as to render a census a physical impossibility. This was clearly seen by Mr. Clark and the Bureau of Fisheries, and the census and investigations were promptly begun. They were carried through in the seasons of 1912 and 1913, but unfortunately, changes in method, personnel and scope, since 1913, have made coordination of results difficult if not im-

possible, and the opportunity for the working out of a rational, scientific policy for the management of our fur-seal herd has forever passed.

Mr. Clark threw his whole soul into the fur-seal question which without doubt he understood more clearly than any other man. He contributed numerous articles on this subject to scientific, technical and popular magazines. Several of his articles appeared in SCIENCE and others in THE SCIENTIFIC MONTHLY. He wrote important parts of the four-volume report of the Fur-Seal Commission of 1896 and 1897, and for the Encyclopedia Britannica and the Encyclopedia Americana.

In speaking of Mr. Clark, Dr. Jordan, with whom he was so closely associated for twenty-seven years, said:

George A. Clark was a university official of the very highest type. Exact, patient, courteous, devoted, absolutely unselfish, his services were of the greatest importance to Stanford as a whole and vitally so to the president, who had in the early days, distressing problems of litigation and finance to deal with as well as with the creation of a new university. In every phase of these problems he had the unfailing help of a secretary who never forgot anything; who never gave false color; and whose only thought was the welfare of the institution he served. George Clark was a noble, loyal and capable soul, one to whom I owe personally very much.

BARTON WARREN EVERMANN
MUSEUM,
CALIFORNIA ACADEMY OF SCIENCES

SCIENTIFIC EVENTS

PROPOSED FEDERAL HEALTH PROGRAM

The Municipal Journal states that complaint has been made by Dr. S. S. Goldwater on behalf of the War Service Committee of the American Hospital Association that the Treasury Department, to which President Wilson referred a comprehensive program of health conservation adopted last winter by a group of leading sanitarians, has so far given no indication of formulating such a program. The President referred the program to the Treasury Department on July 1, said Dr. Goldwater. In the executive order of the President all sanitary or public health activities as carried on by any government bureau were given over to the Treasury Department. Since the President has ordered the centralization of the entire health program, says Dr. Goldwater, the time has come to give adequate attention to the other recommendations. The program asked for the appointment of an administrative head known as the Assistant Secretary of Health or perhaps the Health Administrator, to hold his place for the duration of the war. It also asked for the creation in Congress of a Committee on Public Health. Among the important features of health control in wartime which were formulated by the committee were the following:

The establishing of standard procedures for the control of communicable diseases, including reporting diagnoses, treatment and sanitary supervision, and the adoption of these standards by local authorities. Particular attention to be paid to malaria, hookworm disease, typhoid fever, tuberculosis, and the communicable diseases of childhood.

A comprehensive program for the hygiene of war industries to be prepared and put into effect. Among the matters for special attention should be adjustment of the hours of labor to obtain maximum production without damage to the health of the workers. Special attention should be given to the diseases which seriously reduce the efficiency of farm labor in southern states.

Standards for maternity care and for the preservation of the health of infants and children should be prepared and promulgated. A plan should be prepared and put into effect for the registration and after-care of men enlisted or drafted for military service and subsequently rejected or discharged on account of mental or physical defects. This should include, for example, extension of facilities for the sanitarium and home care of tuberculosis victims and for hospital and home treatment for mental defectives and drug addicts.

To insure the quality and make reasonable the cost of essential drugs and biological products, standard methods of manufacture and standards of potency should be developed and enforced. A comprehensive propaganda of health education adapted to various localities and all classes of people should be developed.

Steps should be taken to provide for the national registration of deaths, births, and cases of preventable diseases. A program should be prepared

for maintaining an adequate supply of properly trained sanitarians, physicians and nurses during the war. The means for the extension of existing training facilities should be provided by the government.

The members of the conference which prepared the program were Dr. John F. Anderson, formerly director of the United States Hygienic Laboratory; Dr. Haven Emerson, formerly health commissioner of New York; Dr. W. A. Evans, formerly health commissioner of Chicago; Lee K. Frankel, vice-president of the Metropolitan Life Insurance Company; Dr. A. W. Freeman, of the Ohio state health department; Dr. Goldwater; Porter Lee, of the New York School of Philanthropy; Dr. W. S .Rankin, state health secretary of North Carolina; Dr. E. G. Williams, state health commissioner of Virginia, and Dr. C. E.-A. Winslow, professor of public health at Yale University.

WORK OF THE BUREAU OF FISHERIES

The *Fisheries Service Bulletin* stated that for years the Bureau of Fisheries has been handicapped for lack of facilities for practical demonstrations and experimentation in the methods of preparing and preserving fishery products. The fishery industries, particularly those concerned in canning and otherwise preserving food products, labor under the serious drawback of ignorance of the scientific principles underlying their operations. There is also an underconsumption of fish, arising in part from the inferior quality of much that is placed on the market and in part from ignorance of the consumer regarding the dietetic qualities and peculiarities of the several species, with consequent improper preparation for the table. As a result there is an annual loss of many millions, probably hundreds of millions, of pounds of valuable fish food. With adequate equipment and personnel provided, the bureau has held that it could render effective aid in developing methods for overcoming such difficulties, and that important results would be achieved in some fields within a short period of time.

The President has approved and authorized an allotment of $125,000 from the fund for the national security and defense to enable the bureau to build and equip in Washington a laboratory for the conduct of work of this character and to provide a temporary personnel. Preparations for carrying out this program are being pushed vigorously, and investigations have been started which, it is anticipated, will yield important results in making available larger quantities of fish for food and in educating the public to the merits of the various fishery products.

As large quantities of fish preserved by salting are lost annually by spoilage and still larger quantities of fresh fish, for which there is no immediate market, are thrown away because of the risk of loss if cured, an investigation for the purpose of developing satisfactory methods for overcoming these difficulties has been inaugurated. Donald K. Tressler, well qualified by training and with practical experience as an analytical chemist for a salt-manufacturing company, has been employed for this work. For the present this experimental work will be conducted at Johns Hopkins University, under the supervision of Professor E. V. McCollum.

A trained worker in domestic science has been employed to carry on experiments with new fishes and fishery products to determine the best methods for preparing these products for the table and to begin the assemblage of material for a publication on fish cookery. In addition, quite extensive experiments have been made in the development of methods suited to the canning of fish in the home, and plans have been laid and machinery has been assembled for the conduct of experiments in drying fish in vacuo.

As rapidly as the services of suitably trained persons for a number of other investigations can be obtained such investigations will be taken up. One of these has to do with the increased utilization of fish waste for manufacture into oil and fish meal or fertilizer.

The Bureau's position for work along the lines outlined has been strengthened further by the provision made by the present Congress for an assistant for developing fisheries and for the saving and use of fishery products.

PUBLICATIONS ON EXPERIMENTAL BIOLOGY AND GENERAL PHYSIOLOGY

A SERIES of monographs covering the subjects of experimental biology and general physiology is announced by the J. B. Lippincott Company under the general editorship of Jacques Loeb, T. H. Morgan and W. J. V. Osterhout. The aim and character of the series are indicated by the following announcement of the editors.

The rapidly increasing specialization makes it impossible for one author to cover satisfactorily the whole field of modern biology. This situation, which exists in all the sciences, has induced English authors to issue series of monographs in biochemistry, physiology and physics. A number of American biologists have decided to provide the same opportunity for the study of experimental biology.

Biology, which not long ago was purely descriptive and speculative, has begun to adopt the methods of the exact sciences, recognizing that for permanent progress not only experiments are required but that the experiments should be of a quantitative character. It will be the task of this series of monographs to emphasize and further as much as possible this development of biology.

Experimental biology and general physiology are one and the same science, by method as well as by contents, since both aim at explaining life from the physico-chemical constitution of living matter. The series of monographs on experimental biology will, therefore, include the field of traditional general physiology.

The following is a list of the volumes announced:

Published

Vol. 1. Jacques Loeb (Rockefeller Institute), "Forced Movements, Tropisms and Animal Conduct."

In Preparation

T. H. Morgan (Columbia University), "The Chromosome Theory of Heredity."

E. M. East and D. F. Jones (Bussey Institution, Harvard University), "Inbreeding and Outbreeding: Their Genetic and Sociological Significance."

H. S. Jennings (Johns Hopkins University), "Pure Line Inheritance."

R. Pearl (Johns Hopkins University), "The Experimental Modification of the Process of Inheritance."

E. G. Conklin (Princeton University), "Localization of Morphogenic Substances in the Egg."

R. G. Harrison (Yale University), "Tissue Culture."

W. J. V. Osterhout (Harvard University), "Permeability and Electrical Conductivity of Living Tissue."

L. J. Henderson (Harvard University), "The Equilibrium between Acids and Bases in Organism and Environment."

T. B. Robertson (University of Toronto), "Chemical Basis of Growth."

G. H. Parker (Harvard University), "Primitive Nervous System."

A. R. Moore (Rutgers College), "Coordination in Locomotion."

There is also announced the publication of *The Journal of General Physiology* under the editorship of Dr. Jacques Loeb, the Rockefeller Institute for Medical Research, New York, and Professor W. J. V. Osterhout, Harvard University, Cambridge, Massachusetts. It will be published bimonthly from the Rockefeller Institute for Medical Research, beginning in September. The editors say:

The Journal of General Physiology is intended to serve as an organ of publication for papers devoted to the investigation of life processes from a physico-chemical viewpoint. As the constitution of matter is the main problem of physics and physical chemistry, so the constitution of living matter is the main problem of general physiology, and in both cases the method of quantitative experimentation is required.

Under the pressure of the demands of medicine and of other professions, physiology has developed in the direction of an applied science, with limited opportunity for the investigation of purely theoretical problems. On the other hand, the physico-chemical methods of analyzing life phenomena have thus far made little inroad into the domain of zoology and botany. Under these circumstances, it has happened that what might be regarded as the most fundamental of all the biological sciences, namely general physiology, has not come to have a journal of its own. It is this condition which the establishment of *The Journal of General Physiology* is intended to correct.

SCIENTIFIC NOTES AND NEWS

DR. WILLIAM WALLACE CAMPBELL, director of the Lick Observatory, University of Cali-

fornia, has been elected a correspondant de l'Institut de France in the section of astronomy.

Sir Joseph Larmor, M.P. for the University of Cambridge, has been awarded the Poncelet prize for the mathematical sciences this year by the French Academy of Sciences.

The Paris Academy of Sciences has awarded the Montyon prize, consisting of 2,500 francs, to Drs. Henri Guillemard and André Labat, of the medical faculty of Paris, for their research work on asphyxiating gases.

At a meeting of July 30, the Paris Academy of Medicine elected, as vice-president for 1918 to succeed the late Professor Pozzi, Dr. Delorme, director of the School of Military Medicine. Conforming to the regulations of the academy, the vice-president succeeds to the presidency the following year.

The Madrid Academy of Medicine has elected Dr. Max Nordau corresponding member. It will be remembered that he has been in Madrid since early in the war.

Dr. Hugh M. Smith, the commissioner of fisheries, was at Woods Hole in the latter part of July for the purpose of collaborating with Mr. William A. Found, superintendent of fisheries of the Dominion of Canada, in the preparation of the draft of the final report of the International Fisheries Conference.

Professor A. Tanakadate, professor of physics in the University of Tokyo, visited Washington in July in the interest of international scientific work.

Dr. Elwood Mead, chairman of the Land Settlement Board of the State of California, has been appointed by Secretary Lane to assist in formulating a national policy for colonizing returned soldiers of the American Expeditionary Forces.

Dr. Edgar Buckingham, of the Bureau of Standards, has been appointed physical associate to the scientific attaché to the American embassy at Rome.

Dr. T. Griffith Taylor, of the Meteorological Bureau of Australia, has been awarded the David Syme Research prize for 1918 for a thesis based on the correlation of Australian physiography, meteorology and climatology, with special reference to the control of its settlement and industrial development.

Dr. Frank J. Monaghan has been appointed deputy health commissioner in charge in Brooklyn to succeed Dr. Frank B. Knause, who has resigned in order to join the Medical Reserve Corps of the United States Army.

Dr. Carl E. Seashore, professor of psychology in the University of Iowa, is conducting investigations on certain problems of hearing as related to the army and navy, and is also devising and standardizing a series of tests for the selection of telegraphers and radio operators. R. H. Sylvester, assistant professor of psychology, is now lieutenant and chief clinical psychologist at Camp Dodge.

Professor Guy F. Lipscomb, of the Clemson Agricultural College of South Carolina, is engaged for the summer on military work in the Chemical Laboratory at Princeton University.

Dr. Olaf Anderson, petrologist at the Geophysical Laboratory of the Carnegie Institution at Washington, has resigned in order to accept the position of government geologist and director of an experimental silicate laboratory for the Norwegian Government, in Kristiania.

Professor E. W. Gudger spent the present summer at the American Museum of Natural History, collaborating on the "Bibliography of Fishes which the museum is now publishing.

Professor Robert F. Griggs, of the Ohio State University, director of the Katima Expeditions of the National Geographic Society, has received a wireless message from this year's field party composed of Messrs. Jasper Sayre and Paul R. Hagelbarger announcing the successful termination of the season's field work in the Valley of Ten Thousand Smokes. The party carried the topographic survey, begun last year, forward to the shore of the Bering Sea, adding some 1,500 square miles to the map and completing a section across the base of the Alaska Peninsula from Katmai Bay to Naknek. This survey will furnish the data for the construction of a topographic map on

the scale of 1/250,000 of the same standard of accuracy as the work of the United States Geological Survey on maps of this scale. In the Valley of Ten Thousand Smokes, beside continuation of the general exploration and securing many valuable photographs, they succeeded in obtaining the first accurate measurement of the temperatures of the vents. For this purpose the expedition was equipped with pyrometers by the geophysical laboratory of the Carnegie Institution. They report the highest temperature measured as 430° C. Although this is subject to correction when the instruments are recalibrated on returning to the states, it probably indicates correctly the order of magnitude of the temperature of the valley. The expedition expects to return home overland *via* the Iliamna route, probably reaching Seattle about September 15.

A WASHINGTON Section of the American Institute of Mining Engineers has been organized. The officers elected are Mr. Herbert Hoover, of the Food Administration, chairman; Dr. H. Foster Bain, of the Bureau of Mines, and Dr. David White, of the U. S. Geological Survey, vice-chairmen, and Mr. Harvey Mudd, secretary.

THE Committee on Mineral Imports and Exports has finished its work of formulating programs for the minimum importation of ores and minerals, and the members of the committee have taken up other work. Professor C. K. Leith has been appointed mineral adviser to the War Industries board from the standpoint of the conservation of shipping, Mr. J. E. Spurr is in charge of the war minerals investigation work of the Bureau of Mines, and Mr. Pope Yeatman continues in charge of the Non-Ferrous Metals Divisions of the War Industries Board.

WE learn from *Nature* that the Electrical Research Committee, which was appointed last autumn, under the auspices of the Department of Scientific and Industrial Research, is at present engaged in superintending a research on insulating materials (fibrous materials, porcelain, ebonite, mica, composite materials) and the water-proofing treatment of insulating windings of electrical machines, in respect of which grants have been made to the Committee by the Research Department, the British Electrical and Allied Manufacturers' Association, and the Institution of Electrical Engineers. The Committee consists of three members nominated by the institution, and three members nominated by the B.E.A.M.A., the nominees of the former being Mr. C. H. Wordingham (chairman of the Committee), Mr. C. C. Paterson, and Mr. C. P. Sparks, and those of the latter Mr. F. R. Davenport, Mr. D. N. Dunlop, and Mr. A. R. Everest.

THE *Journal* of the American Medical Association states that the members of the National Public Health Service of Brazil have erected a monument to Oswaldo Cruz on the grounds of the Public Health Building at Rio de Janeiro. The bronze portrait figure is seated in the professorial chair, with arms resting on a desk, in a peculiarly graceful and easy pose. The inscription reads: "A Oswaldo Cruz, Homenagem do pessoal da Directoria Geral de Saude Publica, 23-III-1903—19-VIII-1909," the dates marking the period of his most productive work, the eradication of yellow fever from Rio. The statue was unveiled with much ceremony recently in the presence of the highest officials of the country. The *Brazil Medico* of June 15 gives an illustration of the memorial.

HARRY KIRKE WOLFE, professor of philosophy in the University of Nebraska, the author of valuable contributions to experimental psychology, died on July 30, at the age of fifty-nine years.

ADOLPH VON FABER DU FAUR, known for his work in mining engineering, died at his home, on August 18 at the age of ninety-two years.

THE death is announced of Dr. J. Kollmann, professor of anatomy in the University of Basel.

THE death is announced of G. Verriest, formerly professor of internal pathology at the University of Louvain, president of the Belgian Académie de médecine and of the International congress of Neurology at Brussels in 1903.

The thirty-sixth stated meeting of the American Ornithologists' Union will be held at the American Museum of Natural History, New York City, November 12–14, 1918, with a business session of the fellows and members on the evening of the eleventh.

The new National Museum has been closed to the public by the board of regents, as all available space in the building has been occupied by the Bureau of War Risk Insurance. It is expected that the museum will be again opened when the new office building of the bureau, at Vermont Avenue and H Street, is completed.

It is stated in the *American Journal of Science* that the Swiss Chemical Society, founded some seventeen years ago, has recently issued the first part (pp. 1–96) of a new periodical, to be devoted to pure chemistry and to serve as the organ of the society. The editorial committee consists of MM. Bosshard, Fichter, Guye, Pictet, Rupe and Werner, all of Switzerland. The present plan is to issue 6 to 8 parts yearly, aggregating from 500 to 1,000 pages; the subscription price is 25 francs per year.

At the last national medical congress in Mexico, it was voted to found a medical journal in which to publish the work of Mexican physicians and surgeons and to keep them informed of the progress of the medical sciences in other lands. The executive committee, preparing for the approaching medical congress, the sixth, has ratified this decision, and Dr. Francisco Bello, of Puebla, has been appointed editor.

Nature states that following upon the establishment of the Kaiser Wilhelm Institute for Research on Iron and Iron-ores comes the news from the German daily press of some preliminary steps that have been taken to found a similar institution for researches on all other generally useful metals. A committee composed of eminent engineers and university professors has been formed to consider the establishment of a metal research institute for the benefit of the German metallurgical industry.

The series of congresses to be held at Monaco to promote the expansion of the thermal, mineral and climatic stations and baths of the allied and friendly nations will deal with hydrology, hygiene, alpinism, thalassotherapy and watering places. In connection with the congresses there will be an exhibition. The whole is under the patronage of the Prince of Monaco. Professor Maragliano, Senator of Italy, has been elected general president.

The President has authorized a loan of one million dollars to the Forest Service for fire-fighting expenses, to meet the serious emergency conditions in the national forests of the northwest and the Pacific coast states. The loan was made from the special defense fund of fifty million dollars placed at the disposal of the President by Congress. It is recognized that the protection of the national forests is an important and essential war activity. Forestry officials regard the present fire season in the northwest as in some ways the most serious with which the government has ever had to cope. Early drouth, high winds, electrical storms, labor shortage and depletion of the regular protective force as a result of the war have combined to make the fire conditions unprecedently bad. Necessity for resort to the Presidential fund is due to the fact that the appropriation bill for the Department of Agriculture for the current year has not yet been passed.

The council of the British Institution of Electrical Engineers is prepared to receive papers, not exceeding 15,000 to 20,000 words in length, on the subject of the "Coordination of Research in Works and Laboratories," and to award a special premium of £25 to the author of the paper which in their judgment best fulfils the object of the discussion. The papers should be sent to the secretary of the institution not later than November 4 next, and it is intended that the one selected shall be read and discussed at one of the ordinary meetings of the institution and shall afterwards be published in the *Journal*.

Nature reports that the following grants of money for research committees were voted by the General Committee of the British Associa-

tion at the meeting in London on July 5: —*Section A.—Mathematical and Physical Science:* Seismological investigations, £100; discussion of geophysical subjects, £10. *B.—Chemistry:* Colloid chemistry and its industrial applications, £5; non-aromatic diazonium salts, £7 7s. 8d. *D.—Zoology:* Inheritance in silkworms, £17. *F.—Economic Science and Statistics:* Women in industry, £10; effects of the war on credit, etc., £10. *H.—Anthropology:* Paleolithic site in Jersey, £5; archeological investigations in Malta, £10; distribution of bronze-age implements, £1; age of stone circles, £15; anthropological photographs, £1. *I. —Physiology:* The ductless glands, £9. *K.—Botany:* Heredity, £15; Australian Cycadaceæ, £17s.; Australian fossil plants, £15. *L.—Educational Science:* The "free-place" system, £5.

UNIVERSITY AND EDUCATIONAL NEWS

IT is officially announced that Yale University will receive, as residuary legatee of the late John W. Sterling, about fifteen million dollars, which will nearly double the endowment of the university.

A SPECIAL three months' course at the New York University and Bellevue Hospital Medical College has been arranged for those who wish to qualify as laboratory assistants in bacteriological work for immediate service in the camps and hospitals. The course is arranged by Dr. William H. Park, director of the laboratories of the New York Health Department, and Dr. Anna M. Williams, assistant director. It will open September 4.

THE College of Physicians and Surgeons of San Francisco has discontinued the teaching of medicine, but will retain a nominal existence for the next three years so as to grant diplomas to such students as shall complete their work satisfactorily in other medical schools.

PROFESSOR M. E. GRABER, fellow in mathematical physics at the University of Chicago, has been elected to the professorship of mathematics in Heidelberg University, Tiffin, Ohio.

DR. E. V. COWDRY has accepted an appointment in the Peking Union Medical College, China.

DR. J. C. WHITTEN, for twenty-four years professor of horticulture and head of the department of horticulture of the University of Missouri, has been appointed chief of the division of pomology of the University of California. Dr. Whitten arrived in Berkeley the middle of August and will begin his work on September 1.

MR. R. DOUGLAS LAURIE, who has been chief demonstrator and assistant lecturer in zoology and lecturer in embryology in the University of Liverpool for some years, has been appointed head of the department of zoology in the University College of Wales, Aberystwyth.

DISCUSSION AND CORRESPONDENCE

HAND-MADE LANTERN SLIDES

AS well expressed by Dr. Gray in SCIENCE, July 12, 1918, p. 43, it is of advantage and often of the greatest convenience to be able to prepare quickly for projection a series of lantern slides showing diagrams, tabulated data, etc. Dr. Gray suggests the use of celluloid instead of gelatin sheets for this. Both the gelatin and the celluloid sheets must be supported by glass plates to hold them flat. Celluloid and gelatin receive the pen wall, and are far less expensive than regular photographic lantern slides.

It was found by the present writer that for all the purposes of simple diagrams, tables, etc., a still simpler method answers admirably. Advantage was taken of the device employed by the lantern-slide artists who made by hand all the lantern slides before photographic ones were invented (1850). The device consists of varnishing the well-cleaned glass with a very thin solution of some hard varnish. When the varnish is dry the pen or brush can be used upon the varnished surface with the same ease as upon good paper. India ink gives the sharpest images and a fine pen is to be used for the writing or drawing.

In preparing the slides the glass is held by the edges between the thumb and fingers

and the varnish poured on until the surface is covered, then the excess is drained off one corner and the glass is placed in a negative rack to dry. For a varnish, any good, transparent varnish may be used. It should be diluted to about one tenth the usual thickness. For the diluting substance xylene, toluene, turpentine, etc., may be used. Varnish diluted with xylene will dry on the glass in about half an hour if the room is dry and warm. If turpentine is the diluent it is better to let the varnish dry over night.

If the slide is to be used for a single exhibition it need not be covered and bound, but if it is to be permanent it is better to protect the surface by covering and binding as with photographic lantern slides.

If the slides are coated with 10 per cent. gelatin and dried one can also use the pen and brush well, but the varnish has proved a better coating.

These varnished glasses for hand-made lantern slides have been in use in different departments of Cornell University for the last six years and have proved very satisfactory.

It may be well to call attention to the fact that nearly all forms of celluloid are inflammable, and slides made of it might bring disaster.

Simon H. Gage

Cornell University,
July 30, 1918

THE HOUSE FLY

To the Editor of Science: The accompanying paper was written by one of my students in elementary biology within one month of the opening of the course. It happened that the house fly was providing the material for laboratory work at that time. And it also happened that several students were attracted by the inconclusive statements in several textboks regarding the function of the so-called *balancers*—which they had already recognized as probably representing the second pair of wings. Experiments were thereupon encouraged to clear up the situation. At first results were conflicting, owing to excusable defects in operative technic. Mr. Whealdon, however, succeeded in reaching unequivocal results, which he embodied in the report that is printed below just as he wrote it.

My purpose in bringing this report to your attention is primarily pedagogical. The facts established by Mr. Wealdon can not lay claim to novelty, as he later discovered. But the method of permitting a student in an elementary course at the very beginning of his work to occupy himself in laboratory hours with a problem he himself had raised and frankly to regard such work as a research—which indeed it is in every essential—to be carried to a real conclusion, quite regardless of the activities of the other students in the laboratory; this method, which subordinates prearranged plans by the instructor to the encouragement of student initiative, may be still sufficiently uncommon in American schools and colleges to justify submitting the accompanying evidence of its efficiency.

Harry Beal Torrey

THE BALANCERS OF THE HOUSE FLY

Report of Some Experiments to Determine their Use

Experiment 1.—I put two flies of apparently equal vigor, but differing slightly in size and coloring of the abdomen, under the influence of ether. From one of them I removed the balancers by means of very sharp pointed scissors. The other I left untouched, using him merely as a check, by which I could compare the actions of the two as they came out from the influence of the anesthetic. This process I repeated with two more flies, then placed them in pairs, one clipped fly with one unclipped, under bell jars, and observed their behavior.

Through the difference in size and marking I was able to identify the unclipped flies and noted that they appear to recover from the influence of the anesthetic sooner than the clipped flies in both cases. As soon as the flies with the balancers removed recovered from the effects of the ether they commenced to rub themselves with their hind legs, stroking their abdomen and wings almost continuously, even lifting their legs quite above the wings and

pressing them down to the table with a stroking movement. The unclipped flies did not do this, and since they appeared entirely normal I allowed them to escape.

The clipped flies continued stroking their bodies and would not attempt flight except when provoked by being touched with a piece of paper which I pushed under the jar. Then their flight was extremely erratic. They seemed to have largely, if not wholly, lost their power of equilibrium. They would fall upside down, and could pursue no direct flight at all.

As a further test I left them under the jar until the following day and repeated observations with the same results. I again put some normal flies in a jar besides the clipped ones to compare action in flight. The unclipped flies had no difficulty in maintaining an upright position while flying about the jar even though they were striking the sides continuously. The unclipped flies stayed in flight much more, and without provocation.

As a final test I took the clipped flies out of the jars and let them go. Although the movements of the wings appeared entirely normal they could not fly, but fell to the floor with an erratic zigzag movement.

Experiment 2.—The procedure in this case was the same as in the first experiment, except that I used five flies instead of two. For each fly that I clipped I imprisoned another, unclipped, that had been subjected to ether for the same period, to use, as in the first experiment, for comparative study. The five from which I removed the balancers I put under one jar. The other five I placed in a second jar beside the first.

These flies I allowed to remain under the jars overnight in order to recover completely from the effects of the ether. On the following morning I found that one of the flies that had been clipped had died; two of the unclipped had succumbed. Probably the dose of ether had been too great.

Upon testing their powers of flight I found that the clipped flies, just as in the first experiment, were altogether unable to maintain equilibrium. Not one of them when released could fly at all, but dropped to the floor with a zigzag darting movement. The unclipped flies flew off in normal flight.

Experiment 3.—Having acquired considerable skill at removing the balancers I put a large number of flies under the anesthetic at once. Then from nine flies I removed both balancers and placed them all under one jar. From eight flies I removed *one* balancer and put them under a second jar; and finally I put seven flies under a third jar. These seven had been subjected to the same dose of ether, but I left them untouched and confined them for comparative study as in the other experiments.

The results accorded exactly with those of the other tests.

(*a*) Flies seemed to notice the removal of the balancers, and kept stroking themselves with their legs about the wings and abdomen.

(*b*) In no case was a fly with both balancers removed able to fly. They could use their wings, but had no power of equilibrium.

But in contrast to this, the flies with only one balancer removed could fly without difficulty, in a manner to all appearances perfectly normal, although sometimes I thought they had slight difficulty in gaining balance at the commencement of a flight.

From these experiments I concluded that the balancers of the fly are intimately connected with his nervous system, and by a distinct and essential function enable him to maintain equilibrium in flight. But just as a man is not deaf who has one ear injured, nor blind though one eye is destroyed, so this power of equilibrium is not essentially impaired without the removal of *both* balancers.

Submitted November 8, 1917.

ROWAN WHEALDON

QUOTATIONS

THE PROPOSED BRITISH MINISTRY OF HEALTH

THE Ministry of Health Bill, which has been under the consideration of Sir George Cave's Home Cabinet, will not, we imagine, prove to be a measure as comprehensive and revolutionary as recent debates and discussions might lead the public to suppose. In this connection

we may recall the suggestion put forward last January[1] by a group of ten members of Parliament headed by Major Waldorf Astor, now Parliamentary Secretary, Ministry of Food. The group advocated the combination and reorganization of existing departments for the setting up of a Ministry of Health, and submitted the heads of a bill providing that so soon as the new ministry had been established by Parliament all the powers of the Insurance Commissions for England and Wales, and all the powers of the Local Government Board, should be transferred to it by order in council, that the health functions of other departments should be taken over at such times as were found convenient, and that there should be power to transfer from the new ministry to other departments any functions transferred to it at first for the sake of convenience but found to be unsuitable for a health ministry to perform. Under this scheme the new ministry would be simultaneously acquiring and shedding powers, and although the method was recognized to be clumsy, the promoters believed that by this expedient matters of national health would be discussed on their merits undisturbed by conflicting claims of rival authorities. Writing on the subject some four months ago, we said that the indications then were in favor of the government bill being a measure to amalgamate the Insurance Commissions in England and Wales with the Local Government Board, leaving the non-medical functions of the latter department to be shed at a later date. There is general anticipation that the medical functions of the Board of Education would also be handed over, but with this possible addition the present position appears to be the same to-day as it was in March. If the bill is introduced in this form, it will undoubtedly come in for much criticism. If it means that the Ministry of Health, to quote Sir Bertrand Dawson's words, is not to have "a bigger horizon than the Local Government Board and Insurance Commission, then we must emphatically say 'No.'" On principles, as he said, there can be no compromise—"the practise of putting the skilled under the control of the unskilled must cease." One plan for preventing the perpetuation of this evil in the new ministry is outlined in the scheme of the British Medical Association, which proposes the establishment of an Advisory Council of experts. This council should hold regular meetings not less often than once a month, should have direct access to the minister, and should have the power of initiation—that is to say, it should have the right and obligation to tender its advice to the minister on any subject which it considered ought to be dealt with, and not merely on such matters as the minister referred to it. It is proposed to meet the objection that the Board's advice could always be overruled by the minister, acting perhaps under the influence of permanent officials—not experts either in medicine or any of the other professions concerned in the prevention of disease or the maintenance of health—by requiring reports of the Advisory Council to be presented to Parliament. What value this expedient would prove to have in practise is a matter upon which there is room for difference of opinion; but, provided the Minister had efficient permanent medical officials in an independent position of direct responsibility to him, it would undoubtedly afford some safeguard against the risk of "putting the skilled under the control of the unskilled."—*British Medical Journal.*

[1] *British Medical Journal*, January 19, 1918, p. 98.

SCIENTIFIC BOOKS

The Ornamental Trees of Hawaii. By Joseph F. Rock. Honolulu, published by the author. 1917. Pp. v + 210. Illustrated with 79 plates from photographs and 2 colored plates from paintings. $3.50.

One of the charms of tropical cities is the profusion of flowering shrubs and trees. The reviewer has had the pleasure of spending several months in the Hawaiian Islands and can say that Honolulu is the most attractive tropical city he has ever visited. Much of this attraction is due to the wonderful variety and beauty of the cultivated shrubs and trees of the streets, gardens and parks.

Professor Rock has given us descriptions of the ornamental trees and also of many of the larger and more showy shrubs. The trees are arranged in natural sequence beginning with cycads and pines, and ending with *Ixora* (Rubiaceæ).

Probably the most striking street trees in midsummer are two species of *Cassia*, *C. fistula*, the golden shower, and *C. nodosa*, the pink shower. The golden shower (plate 43) has long racemes of golden yellow flowers followed by cylindric woody pods, 20 to 30 inches in length, straight and smooth like a musician's baton. The pink shower (plate 44) has dense racemes of pink and white flowers, a gorgeous sight when in full bloom in June. There is a colored plate of this in Mr. Rock's book.

Another showy tree is the flame tree, *Delonix regia* (*Poinciana regia*) (plate 45). This is frequently planted in south Florida, where it is called royal poinciana. The large bright scarlet flowers are in large terminal racemes.

The visitor to the Hawaiian Islands is at once impressed with the number and beauty of the varieties and hybrids of *Hibiscus rosa-sinensis* (page 137). In this country the species is sometimes called rose of China. In Honolulu the hibiscus is commonly used as a hedge plant, the large red or white flowers being conspicuous throughout the summer.

Another common hedge plant is a species of the Aralia family (*Nothopanax guilfoylei*) (page 168). This does not flower in Honolulu, but the white-bordered compound leaves are attractive. The crotons (*Codiæum variegatum*) (page 128) are common in Honolulu as they are in all warm countries. The narrow leaves are variegated with white and red, in some varieties strongly spirally twisted.

The pepper tree (*Schinus molle*) (page 132), with feathery drooping foliage and racemes of small red berries, is extensively planted. The plumeria or graveyard flower (*Plumiera acutifolia*) (page 175), with thick stubby branches, milky juice and white or yellow fragrant flowers, is commonly planted around cemeteries. The flowers are much used for the familiar Hawaiian leis or wreaths made by stringing the corollas on a thread.

One of the most beautifully shaped trees of the parks is the rain-tree or monkey-pod (*Samanea saman*) (plate 33). The crown is slightly convex and very wide spread. Another member of the Leguminosæ is the now thoroughly naturalized algaroba (*Prosopis juliflora*) (plate 36). This tropical American tree is now common in a belt along the shore of all the islands. The pods furnish an excellent feed for stock and the flowers furnish honey. It is often planted along streets.

Professor Rock has devoted considerable space to the palms, of which many species are cultivated in the parks and gardens throughout the islands. To this group 23 plates are devoted. The commonest and probably the most beautiful of the palms is the royal palm (*Oreodoxa regia*) (plate 19), the smooth white trunk being very attractive especially when the plants are growing along driveways. The date palm (*Phœnix dactylifera*) (plate 3) is frequent, and the oil palm (*Elæis guineensis*) (plate 22) is not uncommon. The fish-tail palm (*Caryota urens*) (plate 16) is conspicuous because of the great drooping masses of flowers and fruit; the betel palm, because of the tall and very slender stem. Our California fan palm (*Washingtonia filifera*) (plate 10) is rather frequent.

The visitor to the Hawaiian Islands will find the book very helpful in identifying the cultivated trees. The plates are from excellent photographs and the descriptions give just that information that one wishes to know.

A. S. HITCHCOCK
U. S. DEPARTMENT OF AGRICULTURE

SPECIAL ARTICLES

A COMPARISON OF THE RESPONSES OF ANIMALS IN GRADIENTS OF ENVIRONMENTAL FACTORS WITH PARTICULAR REFERENCE TO THE METHOD OF REACTION OF REPRESENTATIVES OF THE VARIOUS GROUPS FROM PROTOZOA TO MAMMALS[1]

THE behavior of animals in gradients of intensity of stimuli has long been studied.

[1] Contribution from the Zoological Laboratory, University of Illinois, No. 120.

Gradients of temperature, light, moisture, etc., were established by the earlier experimenters with a view to determine the conditions which the animals "preferred." Others tested the reactions of animals in gradients of food and other chemicals in connection with investigation of senses and sense organs. The earlier work was very general, but later the study of the reactions of protozoa in accurately determined temperature gradients[2] was undertaken. In the study of reactions to light, Yerkes[3] first used the cylindrical lens and established definite and accurate light gradients. Mast[4] developed methods of measuring light.

In 1911[5] the writer and Dr. Allee devised a gradient tank in which a definite permanent gradient of substances dissolved in water can be obtained. This was later improved and some of the sources of irregularity eliminated. A figure of the improved tank is shown by Wells.[6] He tested the gradient fully with a conductivity cell and established the general character of the gradient for salts.[7] The writer[8] also devised a gradient cage for air work, air of different character being driven across the respective thirds of a cage so as to give three kinds of air with a slight mixing at the meeting points.

In connection with the study of fishes the writer devised a method of graphing the movements of animals in gradients. This is illustrated on the accompanying chart, graph 1. Here the distance from right to left represents the length of the gradient tank or the distance at right angles to the iso-lines such as isotherms, that might be drawn across it. In making the graphs, movements along the isolines are ignored and only movements which change the position of the animal in the stimulus are represented. Thus in graph 1 the distance from right to left represents the length of the cage. The scales at the sides represent time in minutes, each of the larger units being two minutes. The movements of the animal are drawn to the time and cage length scale. The animal shown in graph 1 (a white-footed wood mouse) remained in the still air (left third) 45 seconds, spent fifteen seconds going the middle of the high velocity third (right third), turned back and returned twice, and was headed toward the still air end at the end of one minute and thirty seconds after the beginning, etc. These graphs can not be made with mechanical exactitude but a high degree of accuracy can be attained. With a watch adjacent to the cage and a little practise there is no difficulty in making such records.

The gradient as encountered by the animal is usually a uniform increase or decrease in the intensity of stimulation except in the air work where there are three steps with two steep gradients between them. In all the experiments cited here one end of the container is near to the optimum for the species. In experiments where the optimum is near the center animals turn back from both ends. There is nothing to cause the animals to move. They do so spontaneously or because of the unusual surroundings. In the narrow tank they must go lengthwise; in so doing they encounter the stimulus. No marked adaptation appears to take place. Goldfish were observed to behave in the manner described below for six hours. Controls in which the animal encounters no change in going the length of the tank are not shown here. In the work cited controls accompany all experiments and have been considered in the case of all work here discussed. A number of psychological points arising in this connection such as learning, Weber's[9] law, etc. are discussed in the papers cited. The purpose of this account is to compare animals of different groups.

In watching the behavior of mammals, reptiles, amphibians, fishes, insects, myriopods, annelids, flatworms and protozoa in gradients of temperature, light, moisture, air velocity,

[2] Davenport, *Expt. Morphology*, Vol. I., pp. 260–262.

[3] Yerkes, Mark Anniversary Volume, p. 361.

[4] Mast, "Light and the Behavior of Organisms," Philadelphia.

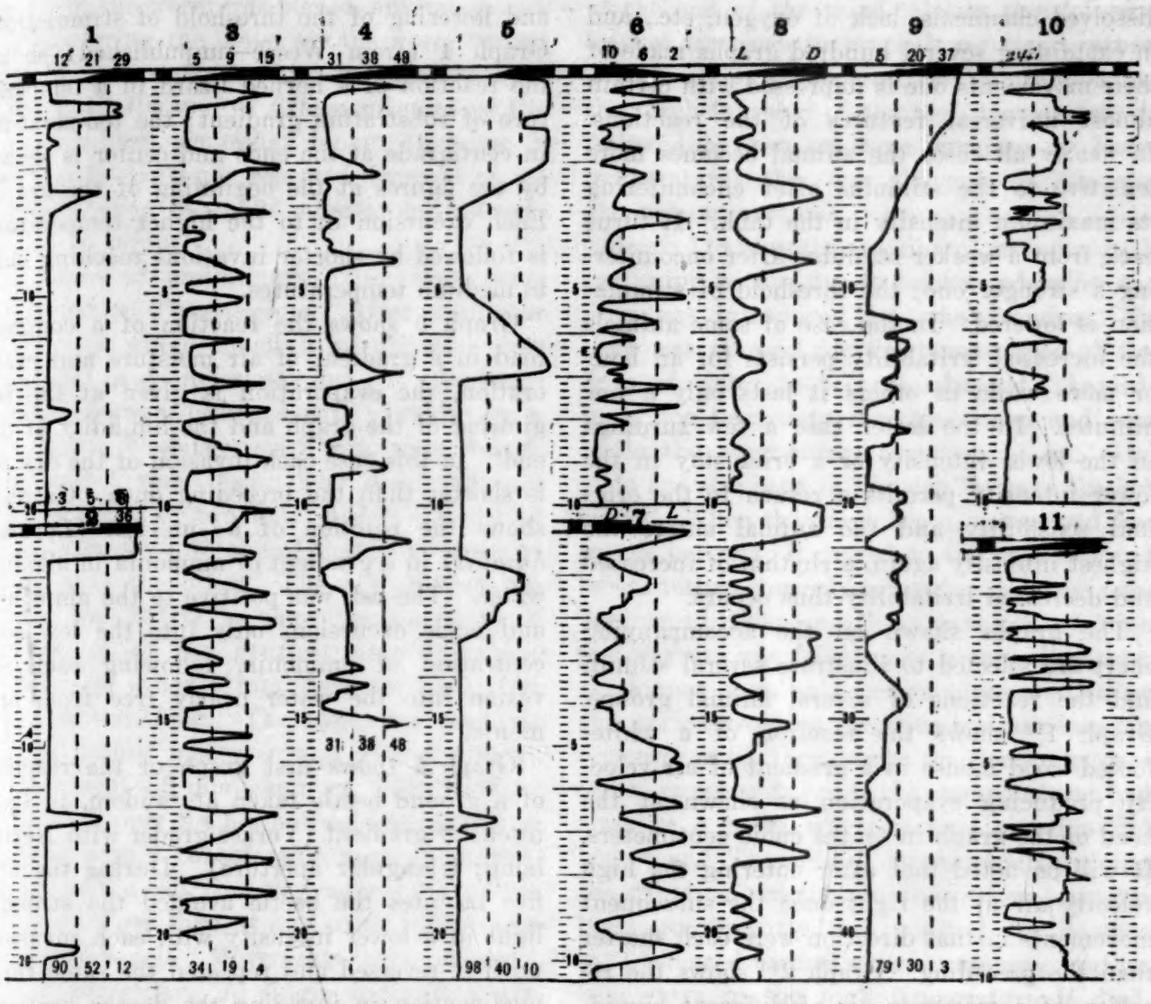
[5] Shelford & Allee, *Jour. Expt. Zool.*, Vol. XIV., p. 226.

[6] Wells, *Biol. Bull.*, Vol. XXIX., p. 223.

[7] Wells, *Jour. Exp. Zool.*, Vol. XIX., p. 246.

[8] Shelford, *Biol. Bull.*, Vol. XXV., p. 81.

[9] Powers, *Biol. Bull.*, Vol. XXVI., pp. 177–200.



Description of Chart. For further details see citations in text.

Graph 1. A white-footed wood mouse (*Peromyscus leucopus noveboracensis* Fischer) in an evaporation gradient due to differences in air velocity. The figures at the beginning of the graph indicate the evaporation for the experimental period in tenths cubic centimeters of water; those at the end indicate air velocity in meters per second. (After Chenoweth.)

Graph 2. A white-footed wood mouse in an air humidity gradient. The figures at the beginning of the graph indicate evaporation and at the end relative humidity in per cent. of saturation. (After Chenoweth.)

Graph 3. A horned lizard (*Phrynosoma modestum* Gir.) in air humidity gradient; figures as in 2. (After Weese.)

Graph 4. A horned lizard in a substratum temperature gradient; the figures indicate temperature in degrees centigrade. (From Weese, unpublished.)

Graph 5. A common toad (*Bufo lentiginosus* Shaw) in an air humidity gradient. Figures as in 2 and 3.

Graph 6. A small sunfish (*Lepomis humilis* Gir.) in an ammonia gradient in alkaline water. Maximum concentration of ammonia at left, 7–10 pt. per million.

Graph 7. A ground beetle (*Platynus cupripennis* Say) in a light intensity gradient.

Graph 8. The same individual ground beetle in an oblique cage intensity-direction gradient.

Graph 9. An earthworm (*Helodrilus caliginosus*) in an air moisture gradient. Figures as in 2, 3 and 5. (From Heimburger, unpublished.)

Graph 10. A single *Paramœcium* in a temperature gradient in which the cool end was near the optimum.

Graph 11. A single *Paramœcium* in a temperature gradient which resulted in death at the end of 12 minutes.

dissolved chemicals, lack of oxygen, etc., and in examining several hundred graphs made of their movements one is impressed with certain almost universal features of the reactions. In nearly all cases the animal becomes more sensitive to the stimulus after encountering its maximum intensity in the tank. It turns back from a weaker stimulus after encountering a stronger one; the threshold of stimulation is lowered. In the case of some animals the increased irritability persists for an hour or more while in others it lasts only a few minutes. In the latter case a few turnings in the lower intensity or a brief stay in the lower intensity permits a return to the original sensibility and the animal enters the highest intensity again, a rhythm of increased and decreased irritability thus occurs.

The graphs shown on the accompanying chart are selected to illustrate several stimuli and the reactions of several animal groups. Graph 1[10] shows the reaction of a white-footed wood mouse in a gradient of air velocity producing evaporation as shown at the head of the graph in tenths cubic centimeters. It will be noted that after entering the high velocity air at the right once the subsequent movements in that direction were each shorter than the preceding. Graph 2[10] shows the reaction of a mouse to air of different humidities. The method of reaction is similar to that to moving air. The relative humidity in the thirds is shown at the end of the graph and the evaporation at the beginning.

Graph 3[11] shows the reaction of a horned lizard to air of high evaporating power, the humidity being shown at the bottom and the evaporation in tenths cubic centimeters at the beginning. The invasions of the dry air during the first three minutes were followed by invasion only into the medium air. These are followed by six invasions of the dry air but with very short stays. Following this, from the thirteenth to sixteenth minute, the invasions reached only just through the medium air. The rest of the graph shows similar modifications and illustrates the rhythmic raising and lowering of the threshold of stimulation. Graph 4 (from Weese—unpublished) shows the reaction of a horned lizard in a temperature of substratum gradient; the temperature in centigrade at the ends and center is shown by the figures at the beginning of the graph. Each excursion in to the higher temperature is followed by shorter invasions reaching only to medium temperatures.

Graph 5 shows the reaction of a common toad in a gradient of air moisture and evaporation, the evaporation is given at the beginning of the graph and the humidity at the end. In this case each invasion of the dry air is shorter than the preceding ones. Graph 6 shows the reaction of a sun fish (*Lepomis humilis*) in a gradient of ammonia in alkaline water. The fish was positive to the ammonia, and made excursions only into the low concentration of ammonia, following each invasion into the water nearly free from ammonia.

Graph 7 shows first graph of the reaction of a ground beetle taken at random, in light intensity gradient (Yerkes grader with Nernst lamp; triangular aperture). During the first five minutes the beetle avoided the stronger light in a lower intensity with each invasion, until it reversed and repeated the same rapid modification in invading the darker portions. After a five minute interval following the end of the first observation, the animal was transferred to a grader in a horizontal position with an oblique cage, cylindical lens,[12] and triangular aperture. The oblique cage was turned so that in moving away from the source of light the animal came rapidly into lower intensities. Graph 8 shows the reaction of the same beetle in this gradient. Each invasion of the darkest part of the cage is followed by turning back a number of times in a comparatively high light intensity. The rhythmic change in sensibility is well illustrated here also.

Graph 9 (from Heimburger) shows the reaction of an earthworm (*Helodrilus caliginosus*) in a gradient of air moisture The first twenty minutes which were spent in the dry

[10] Chenoweth, *Biol. Bull.*, Vol. XXXII., p. 192.

[11] Weese, *Biol. Bull.*, Vol. XXXVII., p. 115.

[12] Shelford, *Biol. Bull.*, Vol. XXVI., p. 309.

air where the worm was placed, are not shown. After entering the moist air the worm turned back in progressively higher moisture contents, until the end of fifteen minutes of the scale; another somewhat longer invasion is followed by the same repeated decrease in invasion between 16 and 26 minutes and between 29 and 36 minutes.

A series of preliminary experiments were performed on *Paramœcium*. After a number of trials in which chambers of different sizes were used, a chamber was cut out of a large drop of beeswax darkened with graphite, on a slide. This chamber was 2 mm. wide, 9 mm. long, and 1 mm. deep. The slide was laid over the edges of two Petri dishes. Water at 36° C. was run into one of these and water at 16° C. into the other. The optimum of the culture was 23° C. as shown by the point of aggregation of the greatest number of individuals in a box 5 mm. deep, 20 mm. wide, and 170 mm. long. The apparatus at hand did not permit measurements of temperature in the 2 mm. x 9 mm. chamber. The position of the slide over the hot and cold water was so adjusted with a considerable number of individuals in the cell, that they aggregated at the cold end rather than at any point in the long axis of the cell. Movements were observed with a binocular. A single individual was then introduced from a diluted infusion.

It is not possible for one person to observe and graph the movements. The writer accordingly observed the animals and stated their position according to a scale, etc., while another person with watch at hand drew the graphs. Graph 10 is typical of what was observed repeatedly. Several invasions of the high temperature occurred before the graph began. This is due to the fact that when water was removed from the cell and another drop added it was necessary to allow two or three minutes for the drop to attain the temperature which accorded with the temperature of the slide beneath it. After the graphing began, an invasion of the high temperature at the end of the first minute was followed by turning in lower temperature. An invasion which did not reach the highest temperature at the end of the third minute was followed by two turnings in much lower temperature. An inspection of the rest of the graph shows that each invasion of the high temperature is followed by two or three turnings in lower temperature; this was the rule in the ungraphed observations.

Graph 11 shows the reaction of an individual, beginning within five to ten seconds after the drop was introduced into the chamber. No time was allowed for the temperature of the drop of water to become adjusted. Accordingly the temperature at the warm end rose while the observations were going on. The slide has also been shifted too far over the hot water. When the graph began the animal was in the hot end; it moved to the cool end and on its return, turned back twice in lower temperatures. Then one long invasion of high temperature was followed by a very short one; three long ones, by a period of rest. During this period avoiding reactions had increased in violence until they began to dominate over other movements and the temperature had risen to a point where normal reaction did not occur. The animal darted rapidly, giving the avoiding reaction in the higher temperatures, so violently that none of the courses were followed up and after a number of rather long stays in the high temperature it died. One striking feature of the behavior is the orientation of the individuals in the long axis of the gradient. This is however apparently trial and error and, as Jennings has noted, when headed toward the optimum temperature they swim ahead without giving the avoiding reaction. The graphs bring out the fact that they give the avoiding reaction at different temperatures in accord with their preceding experience. It is however evidently not correct to assume that the *Paramœcium* distinguishes the difference between the temperature of the water in contact with the two ends of the body as shown by dividing the total distance necessary to give a degree difference by the length of the animal. On this basis Mendelssohn[13] decided that they can distinguish one one hundredth of a degree centigrade.

[13] Davenport, *loc. cit.*

They appear from these observations to distinguish the difference between the temperature of the water where they assume the normal forward course and the point where they give the avoiding reaction. This difference within the range of temperatures compatible with the life of the animal is probably some tenths of a degree, varying with the immediate antecedent experience of the individual.

The method of graphing has been found very useful in making accurate determinations of reaction where modification by environment has been attempted and where accurate determination of sensibility is necessary. One has only to take readings from a graph like number 3, make statistical records, and compute percentages in the thirds, repeating the readings, at ½ min., 1-min. and 2-min., intervals, beginning after ½, 1, 2 minutes, etc., after the graph began to demonstrate that percentage in the thirds, with short intervals at least, is a very unreliable method of making records, unless the reading is done with absolute precision.

The occurrence of the rapid modification of behavior described in practically all the great groups of the animal kingdom leads one to attempt to explain the phenomenon on the basis of some physiological characteristic common to all. In connection with the study of fishes the writer and Allen[14] suggested that in both the case of carbondioxide and lack of oxygen in water the increased irritability is due to increased acidity. In support of this we cited Waller who found that a small amount of carbondioxide increases irritability of nerves.

A similar explanation of the shorter invasions of light in a light gradient in which the Daphnias turn back in a lower intensity as described by Davenport and Cannon, was offered by Loeb[15] who anticipated our conclusion, independently derived, and cited Waller though he attributed the development of acidity to the increased metabolism of the organism due to the stimulation.

Since the phenomenon of modification under consideration takes place in gradients of ammonia in alkaline water, and the fishes concerned are positive to the ammonia, and since such behavior has been noted in the avoidance of cold, darkness, etc., which depress metabolism, thus the hypothesis of increased irritability due to acidity can be maintained only on the assumption that all changes in the environment stimulate the metabolism temporarily. This is not out of accord with the effects of depressing drugs which nearly all stimulate first, for a short time, and then depress.

Whatever may be the correct physiological explanation of the phenomenon, we have noted that the process is similar in the mammal and in the Protozoan. The reactions of both are such as to suggest learning, that is, the possible association of increasing stimulation with stronger stimulation farther on in the course being pursued, though it is hardly to be expected in the Protozoan. If the most intelligent animal behaves like the simplest Protozoan and if pleasure and pain are the basis for intelligence, an analysis of this type of modification may yield data showing that the modification is not essentially different from associative memory. The graphs appear to be but a general statement of the gagging of the chick at the sight of a distasteful species of caterpillar which it has tried on an earlier occasion.

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[14] Shelford and Allee, *Jour. An. Beh.*, Vol. IV., p. 7. Shelford, *Jour. An. Beh.*, Vol. IV., p. 31.

[15] Loeb, "Mechanistic Conception of Life," p. 222.

SCIENCE

A Weekly Journal devoted to the Advancement of Science, publishing the official notices and proceedings of the American Association for the Advancement of Science

Published every Friday by

THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK, N. Y.

Entered in the post-office at Lancaster, Pa., as second class matter